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발달성 고관절 이형성증의 도수 정복술 후 비구 재형성 및 절골술의 역할

Acetabular Remodeling and Role of Osteotomy After Closed Reduction of Developmental Dysplasia of the Hip

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ABSTRACT

Introduction: The purposes of this study were to evaluate acetabular remodeling after closed reduction of developmental dysplasia of the hip (DDH) and to delineate the role of osteotomy.

Materials and Methods: Eighty-four hips with DDH treated with closed reduction and followed until the patient was 8 years of age or older were included in this study. The mean age at closed reduction was 14.0 months (range, 3 to 30 months) and that at the latest follow-up visit was 12.7 years (range, 8.0 to 24.7 years). Osteotomy was performed in 26 hips (31%) during the follow-up period, at an average age of 2.8 years (range, 2.0 to 5.8 years). The acetabular index (AI) and center-edge angle

(CEA) were measured, and osteonecrosis was graded. The treatment outcome was evaluated as satisfactory (Severin grade I or II) or unsatisfactory (III or IV). We retrospectively analyzed the associations among radiographic parameters, performance of osteotomy, grade of osteonecrosis, and Final outcome.

Results: A satisfactory outcome was observed in 67 (80%) of the 84 hips. An osteotomy was not performed in 30 of 34 hips with an AI of <32° and a CEA of >14° at the age of 3 years, and 28 (93%) of these 30 hips showed a satisfactory outcome. Of the 33 hips with an AI of ≥32° and a CEA of ≤14° at the age of 3 years, the 20 that had undergone an osteotomy showed a higher proportion of satisfactory outcomes than the 13 hips that had not (p = 0.01). Three of the 4 hips that showed an unsatisfactory outcome following an osteotomy had an AI of ≥34° at 1 year post-osteotomy. Grade-II, III, or IV osteonecrosis, according to the Bucholz-Ogden classification, developed in 10 of the 84 hips, and these 10 hips had a higher proportion of unsatisfactory outcomes than did those that developed no or grade-I osteonecrosis (p = 0.004).

Conclusion: Hips with DDH showing poor acetabular remodeling after closed reduction may benefit from osteotomy. The AI and CEA at the age of 3 years can serve as one of the guidelines for osteotomy. Continued surveillance for acetabular remodeling is required even after osteotomy.

Keywords: Developmental dysplasia of the hip (DDH)

Closed reduction

Osteotomy

Acetabular remodeling

Osteonecrosis

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INTRODUCTION

Closed reduction is one of the main treatment modalities for developmental dysplasia of the hip (DDH) (1-3). Successful treatment requires continuous remodeling of the hip after closed reduction, and osteotomy is indicated if residual dysplasia persists (3-5). In an effort to perform osteotomy at the appropriate time and to avoid unnecessary osteotomies, many investigators have assessed the factors predicting residual dysplasia (3-16). However, few have provided specific indications for osteotomy (5, 6, 11), which have not been well established yet.

Previous studies on acetabular development after closed reduction have been based on medium-term radiographic follow-up and have had limitations in how they dealt with patients treated with osteotomy (5-7, 13, 14, 16). Some authors did not explain in detail whether patients who had undergone osteotomy after closed reduction were included in the study or not (5, 13). Others excluded the osteotomy group from their study sample and investigated acetabular development only in their nonosteotomy group (6, 14, 16). As a result, they could not show whether osteotomy improved acetabular development, although they recommended osteotomy if an unsatisfactory outcome was anticipated. In another study, osteotomy was considered a bad outcome (7), which may not be justified without presenting the indications for osteotomy. To the best of our knowledge, no study has compared treatment outcomes in patients with and without osteotomy after closed reduction.

The purposes of this study were to evaluate acetabular remodeling after closed reduction, not only in patients who did not undergo osteotomy but also in those who did, and to delineate the role of osteotomy after closed reduction.

MATERIALS AND METHODS

This retrospective study was approved by our institutional review board. We collected cases of dislocated-type DDH treated with closed reduction with the patient under general anesthesia and cast immobilization between December 1984 and April 2014 in a tertiary-care children's hospital and followed until the age of 8 years or older. We excluded hip dislocations associated with neuromuscular disease, arthrogryposis, or congenital anomalies of other organs or systems; hips with teratologic-type DDH; and hips treated with open reduction because of redislocation immediately after closed reduction or that underwent osteotomy concurrently with closed reduction. Two hips that underwent osteotomy before the age of 2 years and 3 hips that underwent osteotomy after the age of 6 years were excluded as well. When a patient with bilateral DDH had been treated with closed reduction of both hips, one side was randomly selected for inclusion in the study. On the basis of these criteria, 84 hips in 84 patients became the subjects of this study. Medical records and serial radiographs were reviewed.

There were 77 female (92%) and 7 male (8%) patients. Seventy-five hips (89%) were in patients with unilateral DDH, 7 hips (8%) were in patients with bilateral DDH in whom the contralateral hip had been treated with open reduction, and 2 hips (2%) were in patients with bilateral DDH in whom the contralateral hip had been treated with closed reduction. Of the 75 unilateral cases, 50 (67%) were left hips and 25 (33%) were right hips. Nine hips (11%) had failure of 2 to 4 weeks of Pavlik harness treatment prior to closed reduction. The mean age (and standard deviation) was 14.0 ± 6.0 months (range, 3 to 30 months) at closed reduction and 12.7 ± 4.2 years (range, 8.0 to 24.7 years) at the time of the latest follow-up, the duration of which averaged 11.6 ± 4.1 years (range, 5.9 to 23.5 years).

An osteotomy was performed in 26 (31%) of the 84 hips at a mean age of 2.8 years (range, 2.0 to 5.8 years). The osteotomies included 12 acetabular procedures, 9 femoral procedures, and 5 combined procedures. The 17 acetabular procedures included 7 Dega osteotomies, 6 Pemberton osteotomies, and 4 Salter osteotomies. Following the femoral osteotomies, the neck-shaft angles range from 100° to 125°, depending on whether the procedure had been combined with an acetabular procedure, and the femoral anteversion angles ranged from 10° to 20°. Fifty-eight hips did not undergo osteotomy, either because the post-reduction remodeling was acceptable or the parents did not follow the recommendation for osteotomy.

On anteroposterior radiographs of the hip, the acetabular index (AI) (17) was measured before reduction, 1 year after reduction, and at the age of 3 years. The center-edge angle (CEA) (18) was measured at the age of 3 years and the time of the latest follow-up. In the osteotomy group, the AI and CEA were also measured at 1 year post-osteotomy. If radiographs made at 3 years of age were not available, the AI and CEA measured on radiographs made at an age older than 2 years or younger than 4 years was considered to indicate the respective value at the age of 3 years. Osteonecrosis was graded using the Bucholz-Ogden classification (19), and the treatment outcome was evaluated using the Severin classification (20). Treatment outcomes in Severin groups I and II were classified as satisfactory, and those in groups III and IV were classified as unsatisfactory.

To determine the intraobserver reliability, measurements were made by one of the authors (C.H.S.) on 2 different days, 1 week apart. To determine the interobserver reliability, the same measurements were made by another author (T.-J.C.) after thorough discussion on how to select the landmark points for measuring the parameters with the first author doing the measurements (C.H.S.). We measured AI and CEA using the lateral osseous margin of the acetabular roof as a landmark point of the acetabulum first, and then repeated measurements using the lateral osseous margin of the acetabular roof. The intraobserver and interobserver reliability of AI and CEA was better when using the lateral osseous margin of the acetabular roof as a landmark point than when using the lateral end of the sourcil. Therefore, we decided to use the lateral osseous margin of the acetabular roof when measuring both the AI and the CEA (Fig. 1). Intraobserver reliability and interobserver reliability were examined using intraclass correlation coefficients (ICCs) (absolute-agreement-type, single-measurement, 2-way random-effect model) for the AI and CEA at the age of 3 years and using the Cohen kappa coefficient for the treatment outcome (Severin classification). Intraobserver reliability was excellent for the AI (ICC = 0.93, 95% confidence interval [CI] = 0.74 to 0.97) and CEA (ICC = 0.91, 95% CI = 0.87 to 0.94) (21). Interobserver reliability was excellent for the AI (ICC = 0.81, 95% CI = 0.48 to 0.91) and the CEA (ICC = 0.88, 95% CI = 0.79 to 0.93). Treatment outcome evaluation showed almost perfect intraobserver reliability (k = 0.89) with 96% agreement and interobserver reliability (k = 0.85) with 95% agreement (22). Since the result of intraobserver and interobserver reliability test was excellent for all radiological parameters, we used the values measured by the first author (C.H.S.) in all radiological assessments.

Scatterplots of the AI and CEA at the age of 3 years were drawn. For the hips that underwent osteotomy, we used the AI and CEA measured at around 3 years of age, prior to osteotomy.

Continuous data were statistically analyzed using the independent Student t test or Mann-Whitney U test, and categorical data were analyzed using the Fisher exact test. A receiver operating characteristic (ROC) curve was used to determine cutoff values for the AI and CEA at the age of 3 years that distinguished between hips with a satisfactory outcome and those with an unsatisfactory outcome in the non-osteotomy group. Pearson correlation analysis was performed to evaluate the relationship between AI and CEA at the age of 3 years and 1 year post-osteotomy. P values of <0.05 were considered significant. We retrospectively analyzed the associations among radiographic parameters, performance of osteotomy, grade of osteonecrosis, and Severin classification.

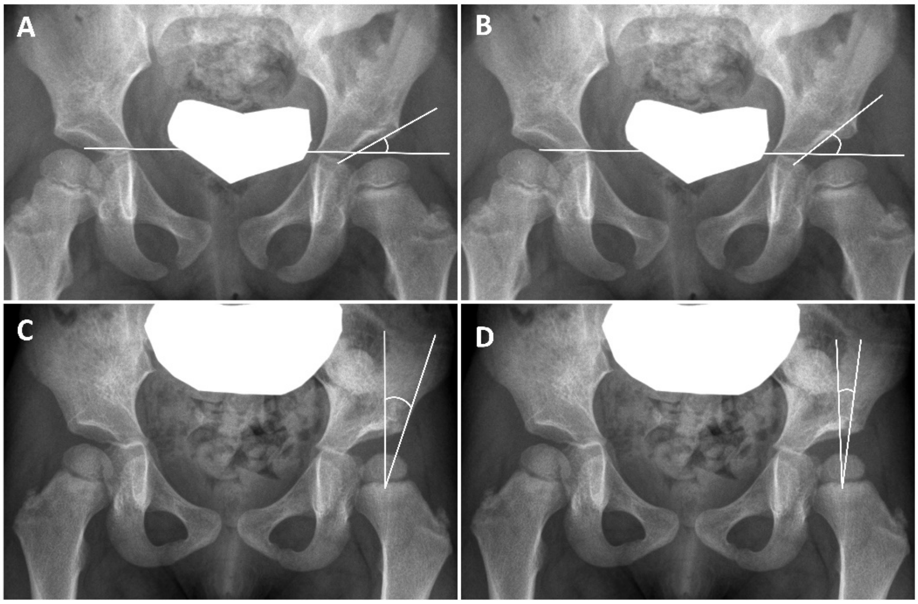

Fig. 1

Figure 1. We used the lateral osseous margin of the acetabular roof instead of the lateral end of the sourcil when measuring both the AI and the CEA. (**a**) The lateral osseous margin of the acetabular roof was used when measuring AI. (**b**) The lateral end of the sourcil was used when measuring AI. (**c**) The lateral osseous margin of the acetabular roof was used when measuring CEA. (**d**) The lateral end of the sourcil was used when measuring CEA.

RESULTS

The mean pre-reduction AI in all hips was 40.2° ± 4.2° (range, 32.6° to 51.2°). The outcome at the latest follow-up visit was rated as Severin group I in 64 hips, group II in 3 hips, group III in 13 hips, and group IV in 4 hips; thus, the outcome was satisfactory in 67 hips (80%) and unsatisfactory in 17 (20%). The osteotomy group had a significantly larger mean AI and smaller mean CEA at the age of 3 years than the non-osteotomy group ($p < 0.001$), but the outcomes did not significantly differ between these 2 groups ($p = 0.565$) (Table 1). A complication developed in 2 (8%) of the 26 patients who had an osteotomy. One of them, who underwent a Salter osteotomy, had migration of a Steinmann pin that required early removal, although the osteotomy site united. The other patient sustained peroneal nerve palsy due to external cast pressure after a Pemberton osteotomy; this fully resolved 2 years after the osteotomy.

A scatterplot of the AI and CEA at the age of 3 years showed a negative correlation between the two (Pearson $r = 20.738$, $p < 0.001$) (Fig. 2). The 58 hips in the non-osteotomy group (Fig. 3) and the 26 in the osteotomy group (Fig. 4) were depicted on scatterplots indicating the outcomes at the latest follow-up according to the AI and CEA at the age of 3 years. An ROC curve applied to the scatterplot for the non-osteotomy group showed the optimal cutoff values for a satisfactory treatment outcome to be an AI of 32°, with 80% sensitivity and 69% specificity (area under the curve [AUC] = 0.791, 95% CI = 0.640 to 0.943, $p = 0.001$), and a CEA of 14°, with 73% sensitivity and 92% specificity (AUC = 0.840, 95% CI = 0.740 to 0.940; $p < 0.001$). Accordingly, scatterplots were divided into 4 zones by lines indicating an AI of 32° and a CEA of 14° (Figs. 2, 3, and 4).

In the non-osteotomy group, 45 hips (78%) had a satisfactory outcome and 13 hips (22%) had an unsatisfactory outcome. Among the parameters compared between those with a satisfactory and those with an unsatisfactory outcome, the AI 1 year post-reduction as well as the AI and CEA at the age of 3 years differed significantly between the groups ($p = 0.01$, $p = 0.001$, and $p < 0.001$, respectively) (Table 2).

Twenty-one (81%) of the 26 hips that underwent an osteotomy had a CEA of ≤14° (Zone 3 or 4), whereas an osteotomy was rarely performed when the CEA was >14° (Zone 1 or 2) (Fig. 2). Thirty (88%) of the 34 hips in Zone 2 (AI < 32° and CEA > 14°) did not undergo an osteotomy (Fig. 2), and 28 (93%) of these 30 hips showed a satisfactory outcome (Fig. 3). All 4 hips in this zone that underwent an osteotomy showed a satisfactory outcome (Fig. 4). In contrast, 20 (61%) of the 33 hips in Zone 4 underwent an osteotomy (Fig. 2). Sixteen (80%) of these 20 hips showed a satisfactory outcome (Fig. 4), whereas only 4 (31%) of the 13 hips in Zone 4 that did not undergo an osteotomy showed a satisfactory outcome (Fig. 3) ($p = 0.01$). Five hips in Zone 1 or 2 underwent an osteotomy because of medial pooling of contrast medium on an arthrogram, markedly increased femoral anteversion, or residual acetabular dysplasia. These 5 hips showed a satisfactory outcome.

Only 4 of the 26 hips that underwent an osteotomy showed an unsatisfactory outcome, and all four were in Zone 4 (AI $\geq 32°$ and CEA $\leq 14°$) at the age of 3 years (Fig. 4). However, we could not find ny association between the outcome and radiographic measurements at this age. When we analyzed the AI and CEA at 1 year post-osteotomy, we found a strong negative correlation between them. (Pearson $\gamma = -0.871$, $p < 0.001$) (Fig. 5). Three of the 4 hips that underwent osteotomy and had an unsatisfactory outcome had an AI of $\geq 34°$ at 1 year after the osteotomy, suggesting the importance of this parameter in predicting the outcome. The other unsatisfactory case (located in the upper left corner of Figure 5) had grade-IV osteonecrosis.

Of 9 hips for which Pavlik harness treatment failed prior to closed reduction, 2 underwent osteotomy and 7 did not. Only 1 of them showed an unsatisfactory outcome, which was due to grade-III osteonecrosis.

Sixteen (19%) of the 84 hips showed radiographic evidence of osteonecrosis, which was Bucholz-Ogden grade I in 6 of them, grade II in 6, grade III in 3, and grade IV in 1 (Table 1). Hips with osteonecrosis that was grade-II or higher showed a significantly higher proportion of unsatisfactory outcomes (6 of 10 hips; 60%) than those with no or grade-I osteonecrosis (11 of 74 hips; 15%) ($p = 0.004$). Of the 10 hips with osteonecrosis that was grade-II or higher, 5 underwent osteotomy and 3 of the 5 showed a satisfactory outcome, whereas only 1 of the 5 that did not undergo osteotomy showed a satisfactory outcome ($p = 0.524$).

Table 1. Characteristics of the osteotomy and non-osteotomy groups

Factor	Osteotomy (N=31)	Non-osteotomy (N=58)	*P* value
Age at reduction* (month)	15.6 ± 5.5	13.2 ± 5.9	0.058[a]
Pre-reduction AI* (°)	41.5 ± 3.2	39.7 ± 4.4	0.053[a]
AI at age 3 years* (°)	33.8 ± 4.7	29.4 ± 4.2	<0.001[a]
CEA at age 3 years* (°)	5.9 ± 9.9	15.0 ± 6.1	<0.001[a]
Gender† (Female/Male)	26/5	56/2	0.047[b]
Laterality† (Left/Right)	19/12	37/21	0.822[b]
Outcome† (Satisfactory/Unsatisfactory)	25/6	45/13	0.793[b]

AI, acetabular index; CEA, center-edge angle

*The values are given as the mean and the standard deviation.

†The values are given as the number of hips.

[a]Student's *t*-test; [b]Fisher's exact test

Table 2. Prognostic factors of treatment outcome in the non-osteotomy group

Factor	Treatment outcome		P value
	Satisfactory (N=45)	Unsatisfactory (N=13)	
Age at reduction* (month)	12.4 ± 5.7	15.6 ± 5.9	0.067[a]
Pre-reduction AI* (°)	39.4 ± 4.5	40.8 ± 4.2	0.376[a]
1 year post-reduction AI* (°)	31.6 ± 4.4	34.9 ± 3.7	0.010[a]
AI at age 3 years* (°)	28.4 ± 3.7	32.8 ± 4.1	0.001[a]
CEA at age 3 years* (°)	16.4 ± 6.0	10.3 ± 3.7	<0.001[a]
Gender† (Female/Male)	43/2	13/0	1.000[b]
Laterality† (Left/Right)	27/18	10/3	0.338[b]

AI, acetabular index; CEA, center-edge angle

*The values are given as the mean and the standard deviation.

†The values are given as the number of hips.

[a]Mann-Whitney test; [b]Fisher's exact test

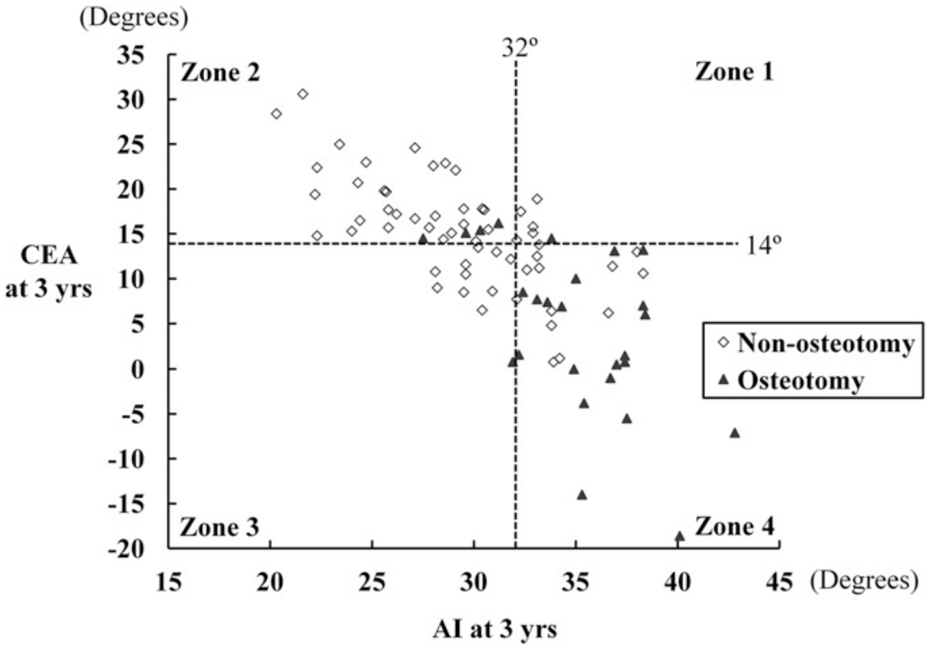

Fig. 2

Figure 2. A scatterplot shows the distribution of AI and CEA at age 3 years in a total of 84 hips which did not undergo osteotomy or underwent osteotomy between 2 to 6 years of age. The scatterplot was divided into four zones by lines indicating an AI of 32° and a CEA of 14° at age 3 years based on the results of the ROC curves.

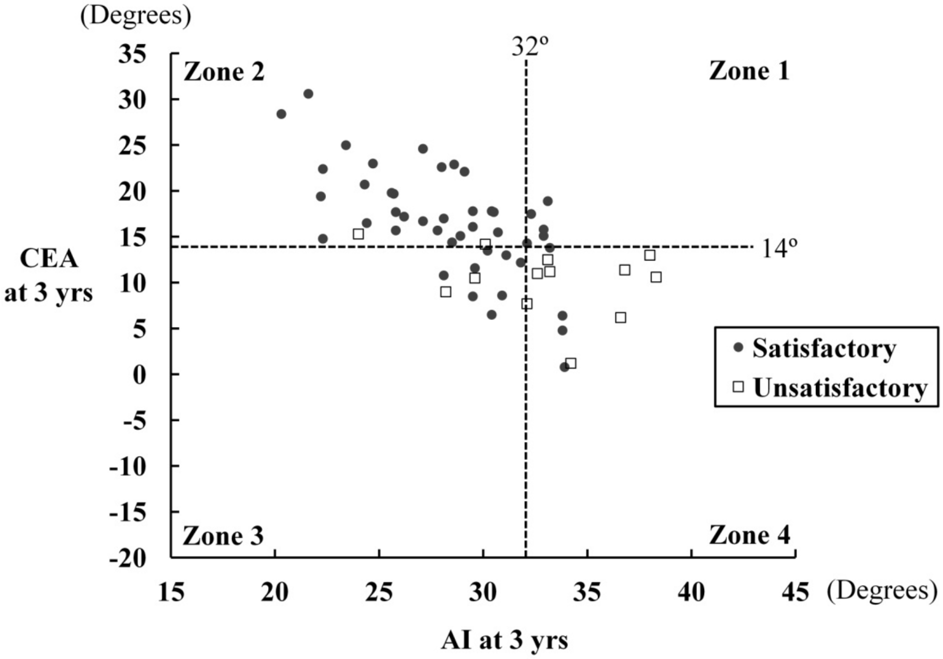

Fig. 3

Figure 3. The AI-CEA scatterplot in the non-osteotomy group (N = 58) shows the distribution of hips with satisfactory and unsatisfactory outcomes according to the Severin classification.

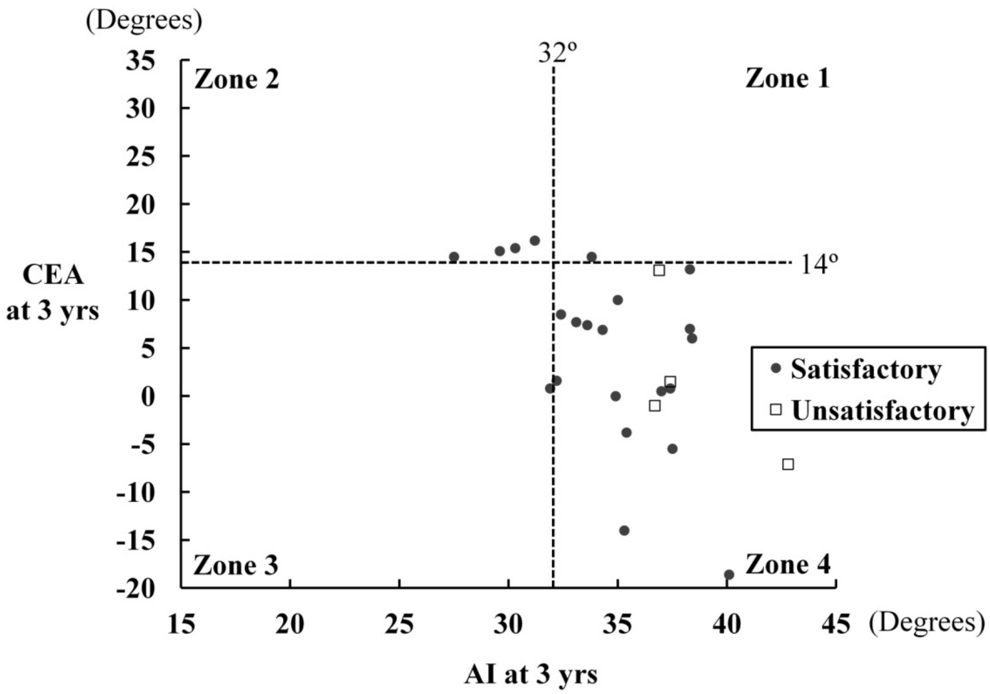

Fig. 4

Figure 4. The AI-CEA scatterplot in the osteotomy group (N = 26) shows the distribution of hips with satisfactory and unsatisfactory outcomes according to the Severin classification. Only four of the 26 hips that underwent osteotomy showed unsatisfactory outcome without any association between the latest outcome and radiographic measurements at age 3 years.

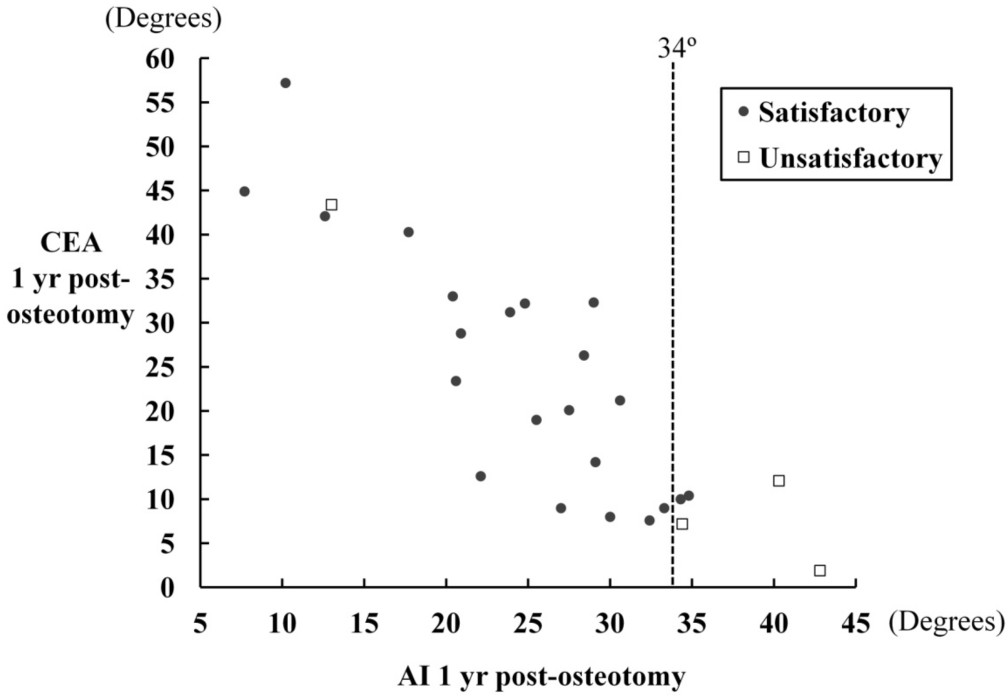

Fig. 5

Figure 5. The scatterplot shows the treatment outcome in the osteotomy group according to 1 year post-osteotomy AI and CEA (N = 26). Three hips that underwent osteotomy and showed unsatisfactory outcome had an AI ≥34° at the 1 year follow-up after osteotomy.

DISCUSSION

In this study, we investigated the outcomes of closed reduction for DDH in subjects with or without subsequent osteotomy. In previous studies, osteotomy or non-osteotomy groups were analyzed separately (1, 3, 5, 6, 13, 14, 16, 23-28). The proportion of satisfactory outcomes in patients with DDH not treated with osteotomy has been reported to range from 45% to 77.5% (1, 3, 5, 6, 13, 14, 16). We are aware of only 1 study of the outcomes of hips that underwent osteotomy after closed reduction, and the authors reported a satisfactory outcome in 74% (24). We believe that we are the first to compare outcomes between osteotomy and non-osteotomy groups after closed reduction of DDH. We did not find a significant difference in outcome between these 2 groups, but it is difficult to interpret our standardized and some parents did not follow the recommendation for osteotomy.

Analysis of the outcomes according to the distribution of the AI and CEA values at the age of 3 years indicated that the AI and CEA at this age could serve as one of the guidelines for osteotomy after closed hip reduction. If the AI remains large and the CEA remains small during the follow-up period, an osteotomy should be considered while sufficient acetabular remodeling potential remains. We usually decide whether to perform an osteotomy when the patient is 3 to 4 years of age. Hips with an AI of <32° and a CEA of >14° (Zone 2) at these ages can be expected to have a satisfactory outcome. However, hips with an AI of ≥32° and a CEA of ≤14° may have a substantial risk of an unsatisfactory outcome and could benefit from an osteotomy.

A conceptual indication for osteotomy would be residual dysplasia; however, specific values of radiographic parameters at a certain age have not yet been established. From ROC analysis, we determined thresholds for the AI and CEA at the age of 3 years that could help surgeons to decide whether to perform an osteotomy. The scatterplot showed that the majority of hips with an unsatisfactory outcome had an AI of ≥32° and a CEA of ≤14° at the age of 3 years (Fig. 3).

Diverse prognostic factors have been studied in patients with DDH who had not undergone an osteotomy. Albinana et al. showed that the AI differed significantly between satisfactory and unsatisfactory hips 12 months post-reduction (4), whereas Yamada et al. reported that the AI at 1 year post-reduction was not significantly different between the 2 groups (29). Age at reduction has been reported to have a significant effect on treatment outcome in some studies (7, 8, 15) but no significant effect in others (10, 14, 29).

Cherney and Westin reported that hips with a pre-reduction AI of >37° were likely to require pelvic osteotomy (9). However, other studies did not demonstrate a significant effect of this parameter (8, 10, 30). These conflicting results might be due to differences in the study designs and subjects. Our data concur with those of Gotoh et al., who suggested that the final outcome in their non-osteotomy group could be attributed to a certain extent to the AI and CEA during the post-reduction follow-up period (11).

In some previous studies, patients who had undergone osteotomy before the age of 4 years were reported to have better outcomes than patients who had done so after the age of 4 years (24, 31). Other studies showed no significant difference in outcome between those who had undergone osteotomy before the age of 3 years and those treated after that age (32-34). We could not find a significant association between the age at osteotomy and the treatment outcome because most (85%) of our patients showed a satisfactory osteotomy outcome and the ages at osteotomy of the 4 patients with a poor outcome of the osteotomy varied.

Of the 4 hips with an unsatisfactory outcome after an osteotomy, 1 had grade-IV osteonecrosis and the others had poor acetabular remodeling at the 1-year post-osteotomy evaluation. These cases signify the importance of continued surveillance of residual dysplasia of the hip until skeletal maturity in the management of DDH. Repeat osteotomy may be considered for hips showing persistent acetabular dysplasia at 1 year after osteotomy. Some hips that showed residual dysplasia 1 year after the osteotomy still had a satisfactory outcome (Fig. 5). They were much improved compared with the pre-osteotomy state and continued to improve over the follow-up period, which suggests that one needs to consider not only the radiographic parameters at a certain time point but also their pattern of change.

In the current study, hips with clinically relevant osteonecrosis (grade II or higher) showed significantly more unsatisfactory outcomes than hips without it ($p = 0.004$), a finding that concurs with those reported by Malvitz and Weinstein (1). The effect of osteotomy on DDH complicated by osteonecrosis has been rarely studied. Bar-On et al. reported that, for hips with DDH and osteonecrosis, the outcome was better when a Salter osteotomy had been done before the age of 4 years than when it had been done after 4 years of age or not at all, although the group that underwent a Salter osteotomy before the age of 4 years included more hips with a higher Bucholz-Ogden grade (35). In the present study, the proportion of satisfactory outcomes was higher in the osteotomy group with osteonecrosis than in the non-osteotomy group with osteonecrosis; however, the difference was not significant ($p = 0.524$), probably because of a type-II error.

In this study, we used the AI and CEA to represent the acetabular configuration and femoral head location and coverage, but these measurements have limitations in the evaluation of DDH in young children. They change rapidly, especially in the age group that we studied (9, 11, 36), and their reliability in that age group is less than perfect (37, 38). However, they are easy to measure on follow-up radiographs and hence are more practical for use in the clinic than arthrography or magnetic resonance imaging (MRI). The center-head distance discrepancy (CHDD) and the Smith centering ratio (8, 39), which are also useful parameters for evaluating DDH, were not used in this study because the CHDD could not be used in bilateral cases and the Smith ratio may be less reliable when a hip has an acetabular deformity (4,8).

Our study had several other limitations. First, because it was a retrospective study, there was no standardized indication for osteotomy. Second, we evaluated only the medium-term radiographic outcomes according to the Severin classification. The final outcome may be complicated by other factors, such as late-developing limb-length discrepancy. Third, the sample size was too small, in some analyses, to verify the statistical significance. Finally, all hips that underwent osteotomy were analyzed as 1 group, regardless of the site and type of osteotomy.

Nevertheless, we concluded that a certain portion of hips with DDH show poor acetabular remodeling after closed reduction and may benefit from an osteotomy. An AI of ≥32° and a CEA of ≤14° at the age of 3 years, along with serial changes in the patterns of measurements and other parameters, can serve as one of the guidelines for performing osteotomy after closed reduction. Continuous monitoring of acetabular remodeling is mandatory even after osteotomy, and repeat osteotomy may be considered for hips showing persistent acetabular dysplasia at 1 year after osteotomy.

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국문초록

목적: 발달성 고관절 이형성증 환자에서 도수 정복술 후 비구의 재형성을 평가하고, 절골술의 역할을 알아보기 위함이다.

대상과 방법: 발달성 고관절 이형성증에 대하여 도수 정복술로 치료 받고 9세 이후까지 추적관찰 한 84예의 고관절이 본 연구에 포함되었다. 도수 정복술 시 평균 나이는 14.0개월(범위, 3-30개월)이었고, 최종 추적 관찰 시 평균 나이는 12.7세(범위, 8.0-24.7세)였다. 절골술은 추적 관찰 기간 동안 26 고관절(31%)에서 평균 2.8세(범위, 2.0-5.8세)에 시행하였다. 비구지수와 Center-edge (CE)각을 측정하였고, 골괴사의 등급을 나누었다. 치료 결과는 Severin I/II는 만족으로, III/IV는 불만족으로 분류하였다. 방사선학적 지표들과 절골술의 시행여부, 골괴사의 등급 및 최종 결과 사이의 연관관계에 대하여 후향적으로 분석하였다.

결과: 84예 중 67예(80%)에서 치료결과가 만족으로 분류되었다. 3세의 비구지수가 32도 미만이고, CE각이 14도 초과인 34예 중 30예에서 절골술을 하지 않았고, 이 30예 중 28예(93%)가 만족스러운 치료결과를 보였다. 3세의 비구지수가 32도 이상이고 14도 이하인 33예 중, 절골술을 시행 받은 20예가 절골술을 시행 받지 않은

13예보다 결과가 만족스러운 예의 비율이 더 높았다(p =0.01). 절골술 이후에 불만족스러운 결과를 보인 4예 중 3예에서 절골술 1년 후 비구지수 값이 34도 이상이었다. Bucholz-Ogden 분류 상 II, III, 혹은 IV 등급의 골괴사는 84예 중 10예에서 발생하였고, 이 10예는 골괴사가 없거나 I 등급의 골괴사가 있었던 예보다 결과가 불만족스러운 고관절의 비율이 더 높았다 (p = 0.004).

결론: 발달성 고관절 이형성증에서 도수 정복술 후 열등한 비구 재형성을 보이는 고관절은 절골술을 하는 것이 이익이 될 수 있다. 3세의 비구지수와 CE각은 절골술에 대한 하나의 가이드라인으로 역할을 할 수 있다. 절골술 이후에도 비구 재형성에 대한 지속적인 감시가 필요하다.

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주요어: 발달성 고관절 이형성증, 도수 정복술, 절골술, 비구 재형성, 골괴사

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